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KSC-FO, National Space Grant Foundation: Internship Final Report

Trash to Gas: Converting Space Waste into Useful Supply Products

My experiences in my internship at NASA Kennedy Space Center have been eye-opening, exciting, and beneficial in multiple ways. Working in the Chemical Analysis Laboratory is a privilege that not many may have; working alongside high temperature reactors, flammable chemicals, and hypergolic fuels all for the betterment of our space technology. There are a multitude of areas that I have been able to gain experience in during my time here, from the methods of analysis and critical thinking in my project, instrumental/data analysis, safety, and communicating in a professional environment. Overall, my project has made me aware of the importance of renewable and sustainable energy not just in space for deep space flight, but right here on earth. NASA has been the trailblazer for technology for quite a while, and if the conversion of waste products into usable gases is optimized for space travel, it will surely "trickle down" to contribute to life on earth as well.

It is essential that all materials in space be used to their fullest potential. During space flight, items like food, packaging, clothing, paper towels, gloves, etc., normally become trash and take up space in a vehicle after use. The purpose of the Trash to Gas project is to utilize waste materials and create useful products like water and methane gas, which is used for rocket fuel, to further supply a deep space mission. These waste materials are currently either burned up upon reentry in earth's atmosphere or sent on cargo return vehicles back to earth: a very wasteful method. The system we used was a thermal degradation reactor with the configuration of a down-draft gasifier. I learned that the design of this reactor was based upon a first generation reactor where only about 10g of waste could be processed. Based upon the findings of the first reactor, a second reactor was made with a new configuration to optimize the process even further. The first step in starting my internship was to learn the procedures for running the experiments with the new reactor. My job was to load the reactor with approximately 100g of trash simulant and control two external ceramic heaters with separate temperature control in order to create pyrolysis and gasification in one zone of the reactor and incineration in a second zone simultaneously. Trash was loaded into the top zone of the reactor to undergo pyrolysis and gasification, while the downdraft gas in the bottom zone experienced incineration to treat tars and other leftover material to maximize the production of carbon dioxide. Through this job, I learned to simultaneously operate heater controls, Labview controls to monitor temperatures and pressures, FTIR instrumentation to monitor extent of reaction, and GCMS instrumentation to gather data on what gases and how much of each were being produced. Other duties included cleaning the reactor after each run, entering data, and other small tasks such as calculating residence times in each part of the reactor, finding a proper sized gas accumulator for the outlet of the reactor, and much more.

My findings showed that the majority of gas produced was in fact carbon dioxide, and minor products included carbon monoxide, methane, and other hydrocarbons. The carbon dioxide produced can be sent to a Sabatier reactor to convert the gas into methane, which can be used as rocket

propellant. In order to maximize the carbon dioxide and useful gases produced, and minimize the unwanted tars and leftover ashen material, I ran multiple experiments with altered parameters such as differing temperatures, flow rates, and location of inlet air flow. According to the data received from these experiments, the process will be further scaled up and optimized to ultimately create a system that reduces trash buildup while at the same time providing enough useful gases to potentially fill a methane tank that could fuel a lunar ascent vehicle or other deep space mission.

I have truly enjoyed the fact that I am able to also do other smaller tasks and projects aside from my main project. I have learned how to use a scanning electron microscope (SEM) and acquired great images and elemental analysis data for my own project as well as for other coworkers' related projects. This imaging instrumentation is used in many chemical engineering labs and will be very useful knowledge no matter what type of research I do in my field. Throughout the semester our lab group also met with a representative from the sustainability group at KSC. We had meetings for brainstorming new ways to incorporate Trash to Gas technology into KSC itself instead of limiting it to space. These discussions developed into brainstorming of many different small projects for sustainable energy, of which two were delegated to me to head up. One project was a proposal to purchase equipment for the KSC fitness center that would allow the exercise machines to generate power for the center as the users exercise. I researched companies that sold this technology and developed a proposal to get this project completed and take KSC one step higher in sustainability. Another proposal was to be made concerning the large amount of polystyrene foam that was being produced and thrown into landfills at KSC. I did research on ways to recycle this material and formed a proposal to purchase a plastic foam compactor to propel the foam recycling movement in the right direction. This proposal has actually become a larger project on which I plan to work. There are possibilities like dissolving polystyrene in a solvent and drying the leftover condensed polystyrene in new molds, shredding it to a powder to use for a compatible laser sintering 3D printer, and many more ideas. All of these possibilities will take much more time, research, and experimentation, which is assigned to me for the summer session.

In general, NASA has given me great exposure to the professional research environment. I have learned day to day lab safety requirements; Personal Protective Equipment (PPE) is very important, especially in our lab since it contains hypergolic fuels and other hazardous chemicals. Gaining experience on how to professionally present data in real meetings and proposals has also been wisdom I could only gain from the work environment. I've developed skills in brainstorming, innovation, problem solving, communication, and resourcefulness all just from my short time here. Learning to improvise when reconfiguring the reactor to work with an optimal performance has been the most hands-on experience in research I have ever had. I look forward to continuing in my work at NASA Kennedy Space Center.